C5.4 Pretensioned Prestressed Concrete Beam

C5.4.2 PPCB LRFD

C5.4.2.1 General

C5.4.2.1.1 Policy overview

Methods Memo No. 184: Policy for LRFD Design
1 October 2007

See C0.

Methods Memo No. 159: Policy on Bulb Tee Use
1 June 2008

See C3.2.6.1.6. (Until the preliminary section is released the memo will be available on the office web site.)

Methods Memo No. 77: Changes to new BTC and BTD Beams (Supersedes Methods Memo No. 66 in cases of conflict)
14 January 2003

Based on discussions with the Iowa Association of Prestressed Concrete Manufacturers and the experience of using the new bulb tee sections on two bridges on I-235, the following changes have been made to the new bulb tee standards (BTC, BTCM, BTD, and BTDM) and related two span standards.

1. Top flange width:

   To reduce beam weight the width of the top flange was reduced from 48 inches to 34 inches. See attached sheet showing modified sections.

2. Top flange edge bars (5c1 and 5c4):

   Because of changes in the AASHTO LRFD specifications and the use of the narrower flange width, the top flange edge bars (5c1 and 5c4) were eliminated.

3. Block out Detail:

   The block out detail was eliminated and the flange width will be constant along the entire length of the beam.

4. Epoxy Coating of Composite Stirrups (5b2 and 6b3):

   To improve the corrosion resistances of the concrete deck the composite stirrups (5b2 and 6b3) will be epoxy coated.

5. Beam Economy (Span Length and Spacing):

   Because of the higher cost of the BTC and BTD, the decision was made to use a minimum beam spacing of 8.25 ft. for the beam standard lengths. This will allow the number of beam lines shown on our typical bridge cross section to be reduced. Using the 8.25 foot beam spacing as a limit, the maximum span length the office will show on the standards will be 115 feet for the BTC section and 130 feet for the BTD section. If the need arises for longer spans, the office will consider developing a 63 inch deep section (BTE).

In addition, because of the narrow beam spacing of the LXD 120 and problems with sweep, we will be dropping it from the LXD standards once the new BTD is released.

6. Use on I-235:

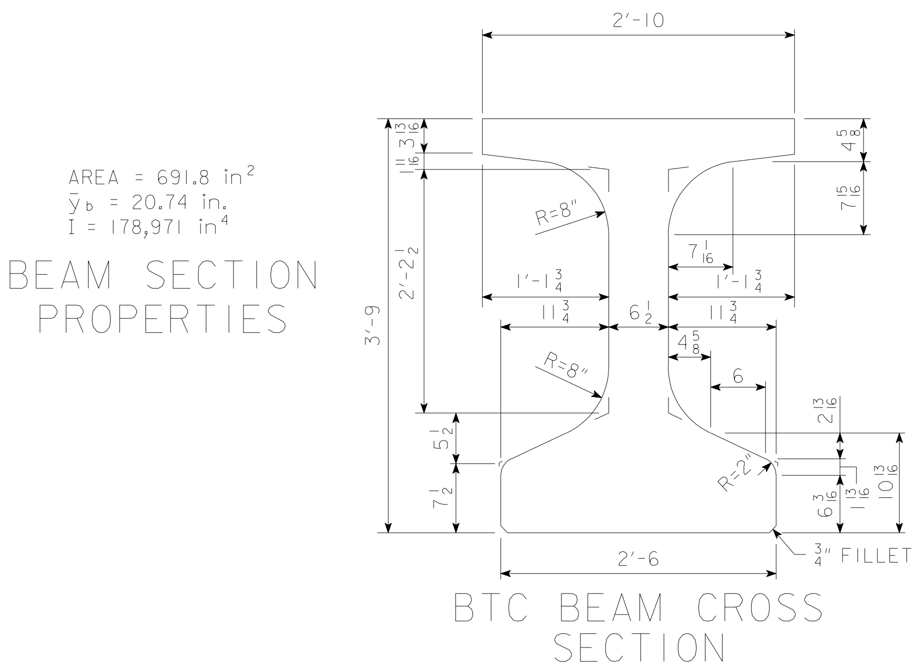
The revisions described above will be used on bridges that are currently under design for I-235. Updated copies of the metric beam sheets have been forwarded to consultants that are preparing plans using the new bulb tee sections.

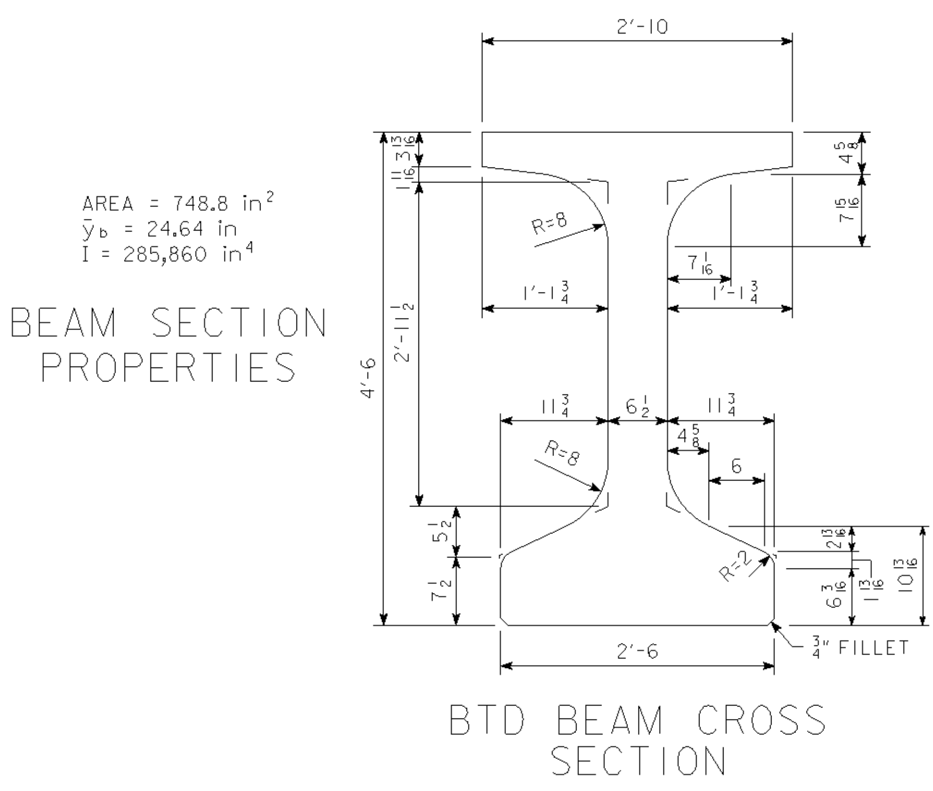
7. Two Span Standards:

WHKS will be revising the 2 span standards to take into account the changes. To improve the economy they will be increasing the beam spacing and eliminating one beam line per cross section. Only the BTD will be used in the standards and the maximum span used will be 130 feet.

8. Release of Bulb Tee Standards:

   The standards for the BTC and BTD are currently being revised to take into account the changes described above, and will be released after they have been reviewed.





Methods Memo No. 84: New Beam Standard Development
24 July 2003

There have been questions about whether the office will be developing a set of new bulb tee standard with depths similar to the current A (32 inch, 810 mm depth) and B (39 inch, 990 mm depth) standard sections for use on I-235. Based on calculations that we did while developing the BTC and BTD, we feel the use of a bulb tee for the shallower depths was not economical. Instead we felt a non-standard design for longer spans could be done using the current standard A and B cross sections. Using higher concrete strengths as specified in Table 5.4.1.4.1.2-1 of the Bridge Design Manual and the larger 0.6-inch strands, the lengths could be increased up to 15 ft. Because of the limited applications, we currently have no plans to develop standards for these longer spans.

For situations outside I-235 where longer A or B may be used because of limits on grade raises, check with the Assistant Bridge Engineer for approval.

Methods Memo No. 73: Use of Special Prestressed Beam Designs
30 December 2004

The special beam designation bid item for prestressed beams should be used when one of the following modifications are made to the standards:

1. Changes in concrete strength.
2. Changes in strand pattern.
3. Changes in beam length.

The beams shall be designated with an "S" for a special beam and the bid item, 2407-0550000 "BEAMS PRETENSIONED CONCRETE, "for English and
2407--100000, "BEAMS PRETENSIONED CONCRETE, "for metric used.
For example, a modified 95 ft D beam would be listed as:
2407-0550000 "BEAMS PRETENSIONED CONCRETE, SLXD95"

A note should be provided in the bid item reference list describing why the special bid item was used. Also, for situations where the beam length may be non-standard or variable, the length should be left off the bid item and the lengths provided in the bid item reference.

The "S" designation should not be used for situations where the lengths of the shear stirrups are modified because of the large haunches. However, a note should be provided in the bid item reference list that the stirrup lengths have been changed.

C5.4.2.1.2 Design information

C5.4.2.1.3 Definitions

C5.4.2.1.4 Abbreviations and notation

Methods Memo No. 77: Changes to new BTC and BTD Beams (Supersedes Methods Memo No. 66 in cases of conflict)
14 January 2003

See C5.4.2.1.1.

Methods Memo No. 84: New Beam Standard Development
24 July 2003

See C5.4.2.1.1.

C5.4.2.1.5 References

C5.4.2.2 Loads

C5.4.2.2.1 Dead

Methods Memo No. 24: Beam Design and Bearing Design, Distribution of Dead Load 2
4 September 2001 (Under LRFD this memo will apply to DC2 and DW loads.)

There have been questions on how to distribute the barrier dead load when designing prestressed beams and steel girders. In the past the office policy has been to distribute the load uniformly to all beams for prestressed beam design, but to distribute the barrier load only to the exterior girder for steel girder design.

In addition, there has been some confusion on the office policy for distributing the overlay (FWS) loads for beam design. Some designers have used the tributary area while others have distributed the load equally to all beams.

The Rating Section policy has been to distribute both the barrier and overlay load equally to all beams or girders for standard roadway widths (widths up to 44 ft.). For roadway widths greater than 44 feet, they have distributed ½ of the barrier load to the exterior beam and the other ½ equally to the next two adjacent beams (¼ per beam). The overlay is still distributed equally to all the beams.

To be more consistent with the rating policy, and to provide a more standard design method for the prestressed beam and steel girder design, the following policy has been adopted:

1. For standard bridge cross sections (roadways up to 44 ft wide), distribute dead load 2 (the barrier and overlay) equally to all beams or girders.
2. For nonstandard bridge cross sections wider than 44 ft follow the same policy as the Rating section and distribute ½ of the barrier load to the exterior beam and the other ½ equally to the next two adjacent beams (¼ per beam). Distribute the overlay equally to all beams in the section.

If you have any questions please check with your section leader.

C5.4.2.2.2 Live

Methods Memo No. 182: LRFD Live Load Distribution for Skewed Bridges with Non-standard Rolled Steel Beams, Non-standard Prestressed Beams or Welded Plate Girders
1 July 2008

See C5.5.2.2.2.

Methods Memo No. 40: Exterior Beam Distribution Factor -- LRFD
28 August 2001

When calculating the live load distribution factor for moment and shear for the exterior beam of beam-supported slab bridges for prestressed beam design, the following guidelines shall be used.

1. For exterior girder design with slab cantilever length equal to or less than one-half of the adjacent interior girder spacing, use the live load distribution factor for the interior girder. Note: The slab cantilever length is defined as the distance from the centerline of the exterior girder to the edge of the slab.

2. For exterior girder design with slab cantilever length exceeding one-half of the adjacent interior girder spacing, use the lever rule with the multiple presence factor of 1.0 for single lane to determine the live load distribution. Note: The live load used to design the exterior girder shall never be less than the live load used to design an interior girder.
3. The special analysis based on the conventional approximation of loads on piles as per AASHTO-LRFD Article C4.6.2.2.2d shall not be used until additional research is available.

The exterior and interior beams shall be designed for the same capacity and the interior beam should generally control the design. If calculations show the exterior beam controlling the design in special situations, then check with your section leader for approval before continuing the design.

If you have any questions please check with your section leader.

C5.4.2.2.3 Dynamic load allowance

C5.4.2.2.4 Earthquake

C5.4.2.2.5 Construction

Methods Memo No. 183: Policy Regarding Construction Loading
1 January 2008

See C5.5.2.2.6.

C5.4.2.3 Load application to superstructure

C5.4.2.3.1 Load modifier

C5.4.2.3.2 Limit states

C5.4.2.4 A-D and BTB-BTE beams

C5.4.2.4.1 Analysis and design

C5.4.2.4.1.1 Analysis assumptions

C5.4.2.4.1.2 Materials

Methods Memo No. 80: Maximum Release and Final Concrete Strength for PPCB
15 April 2003

For the modified standards prestressed beam design, the following guidelines shall be used for concrete compressive strengths:

1. Maximum release compressive (f_{ci}) shall be limited to 7000 ksi. With approval by the Section Leader, the release compressive strength can be increased to 8000 psi.

2. Maximum final compressive strength (f_c) shall be limited to 8500 psi. With approval of the Section Leader, the final compressive strength can be increased to 9000 psi.

C5.4.2.4.1.3 Design resistance and stress limits

C5.4.2.4.1.4 Section properties

Methods Memo No. 97: Revision of MM No. 83 Camber Calculations Using Transformed Sections for Prestressed Beam Design
21 May 2004

The office has recently reviewed the camber values using the transformed section option on the updated ConSpan program, version 2.1.0 by Leap. Based on this review, the Office of Bridges and Structures feels that Leap has addressed the problem with the camber calculations. When using Conspan version 2.1.0 or later versions by Leap, the transformed section camber output shall be used. If you have any questions, please contact the Office of Bridges and Structures, Software Engineer.

C5.4.2.4.1.5 Deflected strands

C5.4.2.4.1.6 Prestress losses

C5.4.2.4.1.7 Moment

C5.4.2.4.1.8 Shear

C5.4.2.4.1.9 Deflection and camber

C5.4.2.4.1.10 Anchorage zone

C5.4.2.4.1.11 Handling and shipping

C5.4.2.4.1.12 Additional considerations

C5.4.2.4.2 Detailing

Methods Memo No. 99: Update of Bid Item Codes for BTC and BTD
16 July 2004

Effective January 1st, 2005 the Office of Contracts will be revising the bid items for all of the BTC and BTD standard beams. For example the bid item for the 115 ft BTD would change from:

Beams, Bulb Tee Pretensioned Prestressed Concrete, D115

To the following:

Beams, Bulb Tee Pretensioned Prestressed Concrete, BTD115

With these updates, the BTC and BTD bid items will be consistent with the bid items of the other prestressed beam bid items.

Methods Memo No. 73: Use of Special Prestressed Beam Designs
30 December 2004

See C5.4.2.1.1.

Methods Memo No. 105: Use of Epoxy-Coated Reinforcing Steel
28 March 2005

See C6.5.4.1.2.

Methods Memo No. 197: Revision to E/M 202 – Embedded Deck Hangers in PPCB
1 May 2008

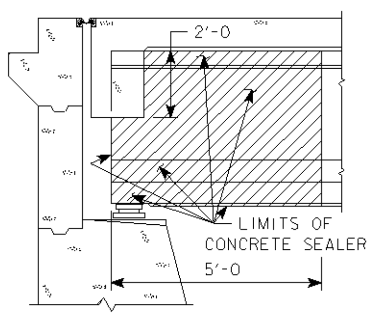
See C11.3.2.

Methods Memo No. 56: Sealing of PCBM Ends
22 October 2003

Because of problems with corrosion of prestressed beam ends at bridge deck expansion joints, the following changes have been made to the office policy and standards.

1. The following note and updated detail have been added to the CADD Standards 4542-4548 (M4542-M4548).

"CONCRETE SEALER SHALL BE FIELD APPLIED TO THE ABUTMENT SEAT AND PRESTRESSED BEAM ENDS IN ACCORDANCE WITH STANDARD SPECIFICATION 2403.21 D. THE SEALING SHALL INCLUDE PORTIONS OF THE PRESTRESSED BEAM-ENDS THAT ARE NOT EMBEDDED IN THE ABUTMENT OR PIER DIAPHRAGMS AS DETAILED ON THIS SHEET. SEALING SHALL BE DONE AT ANY LOCATION WHICH HAS A BRIDGE DECK EXPANSION JOINT."

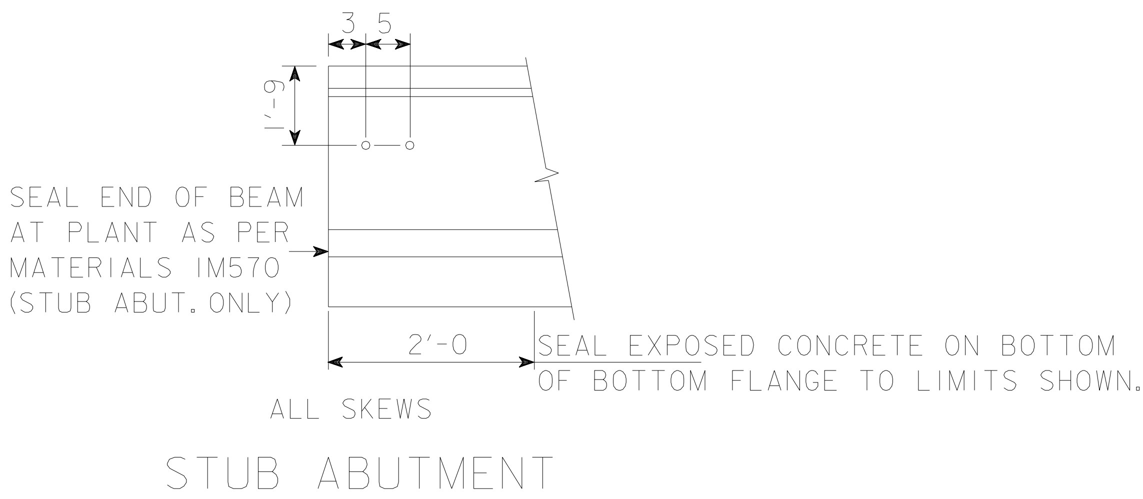


CONCRETE SEALER LIMITS FOR PRESTRESSED BEAM

In addition, the following note has been added to the Prestressed Beam CADD Standards 4600, 4610, 4620, 4630, 4636, 4637, 4638 and 4650 (M4600, M4610, M4620, M4630, M4636, M4637, M4638 and M4650).

"WHEN EXPANSION JOINTS ARE USED, CONCRETE SEALER SHALL BE APPLIED TO THE PRESTRESSED BEAM END SECTION. THE SEALING SHALL BE IN ACCORDANCE WITH MATERIALS I.M. 570 AND 491.12."

2. The following updated detail has been added to the PCBM diaphragm CADD Standard sheet 1036 (M1036).



3. The following note has also been added to the "Estimate Reference Information Notes".

   EST113/MST113

   INCLUDES FURNISHING AND PLACING CONCRETE SEALER ON BEAM ENDS AS WELL AS ABUTMENT SEATS / PIER SEATS AS NOTED IN THESE PLANS.

Please include these changes on all prestressed beam projects currently being detailed that have expansion joints. Until updated standards can be released plan sheets will have to be updated individually.

Appendix for obsolete and superseded memos

Methods Memo No. 66: Guidelines for Using Standard Prestressed Concrete Beams 27 August 2002 (Much of this memo was superseded by MM No. 77 on 14 January 2003.)

With the development of the new bulb tee (BTC & BTD) sections, there have been numerous requests to use them. However, until we have had a chance to fabricate and use the sections in some of our projects, we would like to limit their use.

Therefore, continue to use the current standard sections (A, B, C, D and BT 72 inch (1800 mm)) until further notice, unless the following situations apply.

1. For structures with spans of 120 ft. (36 500 mm) and less, where the standard D beam cannot be used because of vertical clearance issues, the BTC, 45-inch section (1143 mm) may be used with approval from Gary Novey.
2. For structures with spans greater than 120 ft. (36 500 mm) where the standard BT cannot be used because of vertical clearance issues, then the BTD, 54-inch section (1370 mm) may be used with approval from Gary Novey.
3. Overpass locations where the new two span prestressed standards can be used. The two span standards use the new BTC and BTD section.

Vertical clearance issues can be defined as occurring when substantial cost increases are incurred with the grade raise necessary to accommodate the standard "D" or "BT" beam. For Office Relocation work (newly proposed roadway), profile grade adjustments are considered part of the plan development process and therefore not considered an issue.

When considering the use of the new bulb tees, take into account the geometrics of the roadway and bridge. On horizontal curves or transitions into horizontal curves, the haunch-thickening details for prestressed beams are complicated because of super elevations or super elevation transitions on the bridge deck. With the large top flanges (4 ft., 1218 mm wide) of the new sections, the additional loads from excessive haunch thickness may make the section uneconomical or require the beams to be redesigned. The new bulb tees may not be the best choice in these situations.

Methods Memo No. 83: Camber Calculations Using Transformed Sections
11 April 2003 (This memo was superseded by Methods Memo No. 97 on 21 May 2004.)

It has been recently brought to my attention that the ConSpan program may not be calculating camber correctly for Prestressed Concrete beam designs that use the transformed section. In comparison runs that were made, there were large differences in release camber and erection camber using transformed section compared to runs using gross section. For example, a comparison run of the 130 ft standard beam using transformed and gross section gave the following results:

	Release Camber (in.)	Erection Camber (in.)
Transformed Section	5.01	8.85
Gross Section	3.95	6.94
Differences	1.06	1.91

In addition, actual cambers during erection for two bridges recently built using the bulb tee section were lower than estimated cambers shown on plans. Plan values were taken directly from the ConSpan program output using transformed section properties. The actual camber for beams at 42nd St., West Des Moines over I-235 (125 ft. spans) was 1 in. lower than plan value and 28th St., West Des Moines over I-235 (135 ft spans) was 1 ½ in. lower than plan value. In each case, the profile grade had to be revised to avoid excess beam haunches.

While realizing that plan camber is an estimate at best, our hope is to improve camber estimates to avoid potential problems during construction in the future. Therefore, until we can resolve this difference in the ConSpan program with the Leap Company, the following guidelines should be used.

When using ConSpan to analyze a nonstandard prestressed beam, the release and erection camber shall be calculated by hand or using the gross section option in the program. If the program is used to calculate camber values, the designer will need to run it twice. Once using the transformed section for the analysis and second using the gross section for the camber estimates. Please contact our Office if you have questions.

Methods Memo No. 147: Embedded Deck Hanger Forms in PPCB
15 May 2007 (This memo was superseded by MM No. 197, 1 May 2008.)

Some contractors have requested that deck hangers be embedded in beams of prestressed beam bridges. This request has started because we now use epoxy-coated stirrups and the cantilever hangers for formwork support cannot be welded to the epoxy-coating. Generally the request for embedded hangers is just for the exterior girder and not for any interior beams.

There is concern if uncoated hangers are used for the girders at gutter line, then there is a greater chance of deicing salts corroding the top of the beam and reducing the structural capacity of the beam. Because of this concern, we will require that all embedded hangers be galvanized.

Therefore, the following note should be added to prestressed beam bridge plans:

E/M 202

IF DECK HANGERS ARE EMBEDDED IN PRESTRESSED BEAMS, THEY SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A123.